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THE TAXONOMY OF THE AGARICACEAE*

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No classification is perfect; nature recognizes no very marked divisions. As Professor Massee, of Kew, used to say, "Why make a fence? Some rooster is sure to get on top of it with his head on one side and his tail on the other." And often the higher realms of perfection are of little practical use. It is vastly more important to help twenty students to a better knowledge of a group of plants than to tickle the fancy and win the praise of one who no longer needs help. Any one leaving the beaten track is subject to criticism, when he should get only sympathy.

Genera are not now considered sacred entities, but simply groups of species that are more closely related to each other than they are to other groups. New species are usually forced on one; and they entail a lot of extra work requiring initiative, insight, and independent thinking. Examine the shelves of almost any taxonomist and you will find them cluttered up with species he knows are new and is too indolent to describe. The very men who criticize most loudly the multiplication of species would probably lack the courage, ability, and patience to publish new ones.

Nomenclature and the rules of nomenclature are only a means to an end, like the rules of a whist game. No matter how meritorious one's work may be, tradition and custom are as hard as granite rock and the older workers can hardly be expected to change the names to which they have become accustomed. As our knowledge grows, forms of widely distributed species may merge into one and names may be reduced to synonymy. In such cases, it is very unwise and unscientific

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to uphold an error because it happens to be one's own. The injection of the personal element only impedes progress; the mind should be kept open and unbiased, ready for any new light. What crimes have been committed, both in Europe and in this country, in the name of Science! Crimes of ignorance, of carelessness, of egotism, of petty selfishness, of border antagonisms and national hates! But that is human nature, and, after all, the scientists have more than their share of piety.

MORPHOLOGY AND TAXONOMY

Not so very long ago, most American botanists were taxonomists. Now the pendulum has swung the other way. The temptation is very strong for professors in small colleges to limit themselves to a few forms and to go rather thoroughly into their structure and life cycle rather than to attempt to know and classify many forms, which requires a large herbarium and a large library. National and state aid, also, has been largely in the direction of physiology, morphology, and pathology, which is only natural and proper; but it means that taxonomy and the study of plants not strictly economic must be emphasized in institutions properly endowed and equipped for this purpose and that all botanists who enjoy the advantages of such institutions should use them to the fullest extent if the proper balance in the study and teaching of botany is to be maintained.

The old quarrel between the taxonomist and the morphologist is based partly on a lack of sympathy due to ignorance; and one way to restore friendly relations is to increase the breadth of view on both sides. The taxonomic laboratory should really be an "assembly room" for all kinds of information about plants, derived from the geologist, the phytogeographer, the morphologist, and the physiologist. No fact should be overlooked, no source of information should be ignored.

The object of the taxonomist should be not only to arrange his specimens in an orderly way in the herbarium, but to gain the greatest possible knowledge concerning the species; using all the specimens at hand, all notes from various collections, and all that has been written about the species and its distribution, as well as its habitat, abundance, variation, and economic bearing. Such a study is not easy, but involves the highest mental processes. The weighing of all the facts and observations regarding species and their systematic position often taxes the best judgment. It is easy to collect specimens as a fad; it

is not difficult to know a great deal about the objects of nature; but few are capable of pursuing the study of a group until it is rounded out into a perfect and orderly whole, so that others may easily follow and understand. When such a work is done, it is the simplest thing in the world to criticize both the methods and results. It is the object of all devoted nature lovers to add as much as possible to the sum total of natural knowledge. No part of nature is too humble to demand our best endeavors when it is considered in relation to the numberless objects that make up the great universe, and it often happens that what seems very small and unimportant may hold the secret key to something that we look upon as vastly important.

So much for the taxonomist. Let us next see what the isolated worker or professor in a small college can do toward broadening his botanical outlook.

1. He can make sure that he knows by reading or otherwise something of the relatives and relationships of every form he studies morphologically, cytologically, physiologically, or pathologically. This would be a distinct advance. For example, a student investigating the cytology of the scrub pine could learn something of the various species of pines and their near relatives, and a student tracing the life history of a certain species of *Gymnosporangium* could learn to recognize another species of the same genus in case he happened upon it accidentally. It is just as disgraceful for a morphologist not to know the taxonomy of a type he is investigating as it is for a taxonomist not to know why sap rises or the significance of reduction in chromosomes.

2. He can begin, if he never completes it, a local flora of his region, including all groups of plants. Some groups offer excellent opportunities for field study even during the winter, while many of the lower forms are less difficult than the flowering plants. By preserving specimens, taking good notes, and securing photographs or drawings, this work may be made really valuable. There is hardly a locality in America that does not need careful botanical work of this kind. Here in New York City, we have only made a beginning. With taxonomic botanists becoming scarcer every year, it will be a long, long time before we have any adequate knowledge of the flora of this great country. At present, our books only emphasize our ignorance and the gaps in our herbaria remind one of a child shedding his milk teeth. The morphologist could do most of his taxonomic work while out for exercise or on vacation, and it would only give him zest for his more special problems.

3. He can have a compact and easily accessible synoptic collection representing the principal groups of plants, with a few common and characteristic species in each group, so that he and his friends or pupils may obtain some idea of the extent and variety of the plant kingdom. When one takes a tramp or travels, he sees plants, and often these are about the only living things he does see. Now, it would seem hardly fair to one's intelligence to disregard all this wealth of interesting material and be content to go through life both ignorant of it and uninterested in it.

A speaking acquaintance with plants is obtained by observing their form, color, habits, and relationships, rather than by dissecting them. To begin with the microscope is to begin at the wrong end. Let us not be too proud to know the names of the common flowers that bloom at our feet. It is Nature's way with the child; and it is the logical method for the learner in any subject.

COLLECTING THE FLESHY FUNGI

The fleshy fungi, on account of their perishable nature, present many difficulties to the collector, and I have found it almost impossible to secure good specimens without going after them myself. Whenever and wherever fleshy fungi are collected, the following ideal for the herbarium specimen should be kept in mind:

1. Ample typical specimens in all stages, well dried and well preserved without pressing. Specimens in fluid have little value.
2. Full descriptive field notes, especially of perishable characters.
3. A colored sketch as accurate and detailed as possible and a photograph if practicable. Color notes with a color guide at hand may be used with the photograph.

In collecting, it is possible to attempt the entire group of fungi but this is seldom successful. One gets accustomed to looking for certain forms in certain places and it is quite difficult to train the eye to several different sets of conditions. When one collects leaf-spot fungi, he goes more or less into the open and carries a plant-press or vasculum; but when one seeks fleshy fungi, he usually goes into the woods and carries a basket. From the standpoint of collecting pure and simple, the fungi may be divided into three classes: (1) those occurring on leaves, in which the host is pressed just as in flowering plants, (2) those occurring in various places, but requiring no special care in drying for preservation. This class includes the molds, many of the ascomycetes,

all the lichens, practically all the polypores, most of the gasteromycetes, all the Thelephoraceae, most of the Hydnaceae, and many of the smaller and tougher gill-fungi, (3) those requiring the sun or artificial heat for drying, this class including practically all the fleshy gill-fungi, many of the larger fleshy cup-fungi, a few of the gasteromycetes, some of the coral-fungi, hedgehog fungi, and polypores; and all the Boletaceae, this last family being the most difficult for the collector.

It is important that fleshy specimens be allowed to dry as naturally as possible, even if artificial heat is used, since they often assume characteristic shapes in drying. The heat should never be strong enough to cook the specimens, and they should not be pressed in order to mount them in packets. A fresh specimen badly infested with insects may be treated with naphthalene or chloroform in order to prevent the destruction of the specimen before it can be dried. In the mountains of Austria and Italy, where the air is unusually dry, I found artificial heat rarely necessary. In the wilds of Maine and Cuba, I used a special drying oven over a camp stove; at the Lake Placid Club in the Adirondacks, a sunny, steam-heated room; in the Catskills, a large open fireplace; in Oregon, a "biplane" made of window screens suspended over a wood stove; in Virginia, a garret over the kitchen stove; on the Vanderbilt estate in North Carolina, the ordinary sunshine; and in Jamaica and Mexico, a drying oven over two tin oil lamps, which were often kept going all night.

It sometimes happens that a botanist may know a distant region better than the one in which he lives. When one goes away for a definite object, he can devote his time to that object, while at home his attention is often absorbed with numerous other interests. In my own case, while I have been able to get a fair knowledge of the species occurring in the immediate vicinity by getting up at an early hour in the morning, I have given rather special attention to northern New York, Maine, Virginia, North Carolina, Washington, California, Mexico, Jamaica, Cuba, and many parts of Europe, the fungi brought back from these regions amounting to over 30,000 herbarium specimens.

The mycological herbarium at the New York Botanical Garden contains about 200,000 specimens, half of which were obtained from Mr. J. B. Ellis, who at the time of his death had described more new species than all other American mycologists together. The value of such a collection can hardly be overestimated. From a purely botanical standpoint, it is highly important that original and representative

specimens of all groups of plants be thus preserved for purposes of reference and comparison; and, since questions of origin, distribution, and variation always enter into studies of classification, it is desirable to have these collections as complete as possible. From the standpoint of applied botany, the vast number of destructive plant diseases caused by fungi relate this subject very intimately with horticulture, agriculture, forestry, and allied sciences.

Aside from the use of the collection by systematic botanists, plant pathologists, and foresters, there is a large and increasing interest manifested in fungi by the plant-loving public, drawn by fondness for the queer and unknown, or attracted by bright colors and peculiar forms, or by their extensive use as food. To all these, the collection affords the keenest pleasure and offers opportunities for further knowledge and enjoyment.

This collection of fungi is to be the basis of nine volumes of *North American Flora*. As the various groups are worked over and new species published, the number of type specimens in the herbarium will be greatly increased. Students, collectors, and investigators throughout the country will continue to send in specimens for determination and comparison, and will come here to consult not only the originals, but the array of additional specimens that show the variation and the geographical distribution of given species and groups of species.

It is hoped that important contributions may in time be made to questions of geographical distribution on the basis of various collections from distinct regions. For the purpose of recording the distribution of species conveniently and quickly, a chart has been prepared, copies of which may be properly marked and pasted on the inside of the species covers, to show at a glance just where a particular species is known to occur.

If one wishes to distinguish specimens from different regions in the herbarium, he may use gummed paper markers of different colors on the species covers, or simply indicate the regions by numbers or letters, as shown in the following table:

I. North America.....	Na..White	VI. India.....	In..Orange
II. Tropical America.....	Ta..Red	VII. China and Japan.....	Cj..Yellow
III. South America.....	Sa..Blue	VIII. Malaya.....	Ma..Brown
IV. Europe and Siberia.....	Es..Gray	IX. Australia.....	Au..Pink
V. Africa.....	Af..Black	X. Islands.....	Is..Green

THE MECHANICAL SIDE OF THE HERBARIUM

The mechanical side of the fungous herbarium presents fully as many difficulties as the preparation of specimens in the field. Some of the specimens are small and flat, while others are large and bulky; some are tough or woody, others are fragile; some may be poisoned once for all, while others require constant attention to prevent their destruction by insects.

The model fungous herbarium contains all the specimens of a group in a single series and is at the same time neat and easily consulted. Let us begin with the ordinary herbarium sheet to which is attached envelopes of various sizes containing the specimens. It is never desirable to leave the specimens exposed on the sheet as in flowering plants, although this old method had obvious advantages. In case of small specimens that might be lost, they are best enclosed in pill-boxes or small elongated paper boxes, or in open cradles with cardboard bottom and sides of cypress or cork strips attached with glue. Such containers should always be placed within the envelopes before mounting. A very convenient paper box is made with a loose cover so as to avoid delay in opening it. The more specimens that are fastened to sheets, the less trouble there will be.

For specimens too large to fasten in this way to sheets, boxes of various sizes will have to be used and these should be either glued to good cardboard, only one species to a card, or placed in a light wooden tray that fits the pigeon-hole. In order to prevent the great waste of time incident to examining a large amount of material and in opening boxes or packets, a set of sample specimens may be mounted in uniform boxes fastened to cardboard and covered with transparent tops made of gelatin or celluloid. With a set of these samples, hundreds of specimens may be consulted and compared in a few minutes. Such an arrangement is peculiarly adapted to universities and small herbaria where distribution is not so much an object as is the determination of specimens. There still remains the odd lot of boxes too few to mount on cardboard which can only be placed in a wooden tray and listed on the outside of the tray. Such individual representatives of different species cannot be distributed at once through the herbarium, but must wait until additional material allows the use of the cardboard.

The preservation of fungi against insects has always been a difficult problem for the curator. Many methods have been tried in

various herbaria without complete success. Carbon bisulfid has been mainly used in this country, but the results are not satisfactory. Corrosive sublimate, so extensively employed for flowering plants, is not only valueless but decidedly harmful to many of the higher fungi, since it alters or destroys their surface characters and often changes their substance to a marked degree. It is much better to lose some specimens than to have the whole collection thus altered. In the case of large woody specimens, also, it is very difficult to secure sufficient penetration to preserve the interior portions.

The substance I have used with great success is naphthalene flake, of the best quality. Experiments conducted here have shown that adult insects are killed in a few hours when placed in a box with this substance, and it is probable that those emerging from the pupa stage succumb in less time. Specimens are treated when first obtained, and those peculiarly susceptible are kept in an atmosphere of naphthalene more or less all the time. In going through the collections, when a packet or box is found containing insects, a spoonful or more of naphthalene is added and the incident closed. Possibly there are insects not yet acquired or some that do not thrive in this region that are not amenable to this treatment, but it has been more satisfactory here so far than any other method I have seen tried.

All fungi found upon leaves are treated with corrosive sublimate. This is done chiefly to preserve the leaves intact, the fungi being so small that, with few exceptions, insects would hardly do them serious damage. All other fungi, particularly the conspicuous forms known as mushrooms, bracket fungi, etc., are placed in boxes with naphthalene flake for several weeks or longer, according to the season, before distributing them in the herbarium. Groups peculiarly liable to attack are examined once or twice a year and fresh naphthalene added when necessary. After a box collection has been once cleared of pests, it is not so difficult to keep them out, with a fair amount of precaution and vigilance.

THE ARRANGEMENT OF ILLUSTRATIONS

The ideal herbarium contains specimens arranged in a single series, with all notes and illustrations classified with the specimens. The maintenance of more than one series is both a complication and an aggravation. However, throughout most of Europe, illustrations are kept in a separate series, just as exsiccata usually are; and I might remark that both exsiccata and illustrations should be in duplicate so

that one set may be distributed with the specimens and the other set kept on file for ready reference. At Kew, a splendid set of portfolios has recently been made to hold the large number of colored illustrations made by Cooke, Massee, and others. In the Fries herbarium at Upsala, the drawings are mounted on cardboard and kept in a separate case. The advantage of having colored illustrations readily available when fresh specimens are brought in for comparison appears at once, since characters are then used for determination which disappear when the specimens are dried. Herbarium specimens are rarely consulted for comparison except with dried material. It may also be desirable to know whether there exists in the collection a good illustration of the specimen in question so that steps may be taken to fill the gap as new collections are brought in. It has been decided to adopt the following arrangement with our collection of fleshy fungi:

1. Keep a set of colored drawings and photographs convenient for ready reference.
2. Keep all other drawings, such as those of sections, spores, etc., with the specimens in the herbarium; and prepare a duplicate set of photographs and colored drawings for the herbarium whenever practicable.

Water-color paintings should be kept in a perfectly dry, dark place. Naphthalene, camphor, and carbon bisulfid are not particularly harmful to water-colors, but sulfur dioxid, hydrogen sulfid, and fumes of ammonia or acids should be carefully guarded against. The colors used should be the best and most permanent on the market, and each color should be actually tested by the artist if possible before it is used.

THE NEED OF AN AMERICAN ILLUSTRATED WORK

While on the subject of color, I wish to remark that one of the greatest needs of mycology in this country is a comprehensive illustrated work on the larger fungi. The various countries of Europe are well supplied with such works, some of them quite old and very elaborate. Had it not been for these books, the work of many mycologists would have been practically lost or left in such a state as to be more or less useless. America has nothing to compare with any of the illustrated works on fungi in Europe. The need of such a work is fully realized by all; but it would require not only a well-equipped herbarium and library, but also a considerable amount of money, probably

\$50,000, to carry out such an undertaking. Artists would have to paint the plants in the fresh condition where they grow and this would necessitate reaching various parts of the country during the growing season, although a large beginning might be made in any given locality. The plates should be prepared and reproduced in the best possible manner, and accompanied by accurate and comprehensive descriptive text. Such a work would be useful to the forester who wishes to protect his trees from wood-destroying fungi, to the collector of edible mushrooms who wishes to use them for food and to guard against poisonous species, to the student in college or university, and to the general nature-lover in whatever part of the country he might live. There is nothing that would give a greater impetus to the study of fungi in all parts of North America than the publication of such a great illustrated work.

THE CLASSIFICATION OF THE GILL-FUNGI

Coming now to a discussion of the taxonomy of the Agaricaceae in a more limited sense, the history of mycology in Europe shows that some of the older men, like Schaeffer and Bulliard, devoted their attention to describing and illustrating *species* and thought very little about *genera*; while others, like Persoon, Roussel, Gray, and Fries, attempted to improve upon the rather primitive divisions of Linnaeus. Then came the general adoption of the Friesian classification through the publication and wide distribution of the *Systema* and Saccardo's *Sylloge*, followed by demands for improvement from Quélet and Patouillard in France, Karsten in Finland, Hennings in Germany, and Underwood and Earle in America.

When one travels from country to country and from one herbarium to another, he gets accustomed to changing his nomenclature as he does his language and his money. The claim of "existing usage" put forward by some has no value whatever unless it refers to the names used in Saccardo's work, which is merely a convenient, though disorderly, compilation of species as they are published, arranged according to a system in vogue when the work was started many decades ago. Karsten, a pupil of Fries, questioned the latter's classification because based on too few characters. Patouillard and Fayod considered microscopic characters of great importance, while Maire goes so far as to include cytological characters.

What we need in America is a classification that is impartial, practical, and modern, including all the improvements possible and

based on the study of American rather than European material. We want no "pounds, shillings, and pence" in the form of cumbersome subgenera, subsections, and subspecies. The taxonomist must know but not recognize varieties, which are essential to the gardener, the physiologist, and the plant breeder. Let the grouping be as natural as possible, but artificial when conducive to clearness. The absence of sex in the gill-fungi gives one considerable liberty and our knowledge is still far from complete. A system of classification representing the genetic relationships of the higher fungi is hardly yet in sight. If the species could be collected and grown together under cultivation, the glad day might be hastened, but they cannot. Every house has a garret; so has every family a genus or two which catch everything not wanted elsewhere. Do not be too particular with the misfits, but do not throw them out of the window; they may fit in when you move to the next house.

In seeking suitable characters for classification, one must use what comes to hand, and the same characters may not be available for different groups. The best and most constant primary character for the gill-fungi seems to be the color of the spores. Earle tried to use the "partial veil" but failed on account of its evanescent and variable character. The form and surface markings of the spores may be quite characteristic, as in *Entoloma* and *Inocybe*, but other good characters should be associated with them. I believe that Patouillard goes too far with microscopic characters, and, moreover, that these should be used in keys as little as possible, in order to save time and trouble. A key character need not necessarily be the most important generic character, but only the most convenient.

Recent researches on color in the flowering plants have shown this character to hang on a very slender thread sometimes in that group, but what would we do in the fleshy fungi without the recognition of color? Poisonous properties alone would hardly seem to be a sufficient basis for the separation of species, and still there might be a good practical reason why they should be recognized in certain instances. I have in mind the variations in the poisonous properties of *Venenarius muscarius*, *V. pantherinus*, and *Chlorophyllum molybdites*, and the separation of *Clitocybe sudorifica*, a poisonous species or variety, from *Clitocybe dealbata*, generally considered harmless but not differing morphologically from *C. sudorifica*. Ordinarily, physiological properties would seem to have no taxonomic standing, but

they might be suggestive and lead to more careful morphologic research.

The many changes made in generic and specific names are to be deplored, but they are unavoidable. As already intimated, the systems of classification in vogue in Europe were not in harmony and were based on different conceptions from ours, so that they had to be worked over and adapted to our needs. The American code of nomenclature adopted for *North American Flora* over a decade ago has been found to work remarkably well and we see no reason to change it, even if such a thing were possible, for the set of compromise rules recently formulated which will never be consistently followed anywhere in the world. People ask me why I take up *Melanoleuca* for dear old *Tricholoma*, not knowing that Bentham used *Tricholoma* for a genus of flowering plants as early as 1820. They say it is a shame to discard *Amanita* and use *Venenarius* for our most poisonous mushrooms, little dreaming that in the long ago *Amanita* and *Agaricus* meant the same thing and we could not keep them both. It is not my fault that the old fellows did their work so poorly and with such a delightful disregard of priority rights.

Neither is it my fault that American material has been so poorly determined by European mycologists. They have no more interest in America than we have in the Fiji Islands or in Timbuctoo, and when they receive our specimens they are very apt to be reminded of a similar European species and be satisfied with that. Then, there is the great difficulty in studying dried specimens of fleshy fungi unless one has seen them in the fresh state. Specimens lose something in drying that can never be replaced. That is why I have often sat up half the night over the drying oven when the hunting was good in one of those far-off, wild, and virgin forests "somewhere" in North America or Europe.

I wish now to bring to your attention the system of classification I am using for the gill-fungi. Much time might be devoted to the grouping, the characters, and the descriptive terms employed, but a prolonged discussion of these details would only weary you. I prefer rather to outline briefly the main groups of this family and to illustrate them with colored slides of some of the more common and interesting species.*

NEW YORK BOTANICAL GARDEN.

* At the conclusion of the paper, lantern slides were used to illustrate the classification of the gill-fungi.